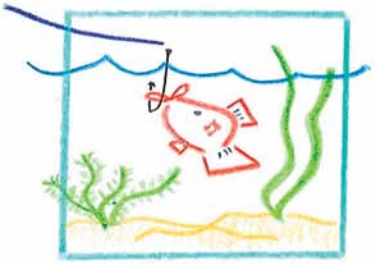
# **Energy Source:** Biomass

**BIOMASS** is living or recently living organic matter from plants and animals. Biomass can be used as a fuel source because plants and other photosynthesizing organisms (such as algae) convert the sun's energy into stored chemical energy. When animals eat these photosynthesizing organisms, this stored energy is passed on up the food chain.


YESTERDAY

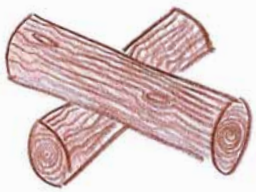

TODAY

Biomass is considered a **RENEWABLE** energy source because we can quickly regrow plants.

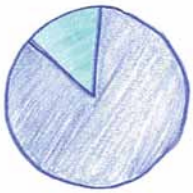
How do we harness the energy stored in biomass? We **BURN** it!

The heat produced is used to boil water, generating steam that will turn a turbine and produce electricity. We can also burn **METHANE** emitted when biomass decomposes to produce electricity.

Wood and crops (such as corn) are the most common forms of biomass used to generate electricity. Garbage and animal manure can also be used. For example, farmers can put livestock waste into a digester to generate methane.



There are 76 waste-to-energy plants in the United States. While currently more expensive to run than other electrical plants, they also reduce the amount of garbage we add to landfills. We do have to be careful about burning items like batteries and light bulbs that can release toxins into the environment.


**85%**
OF HOUSEHOLD TRASH IS ABLE TO BURN

Over millions of years, the stored chemical energy in biomass is condensed and transformed into fossil fuels. So the **ENERGY DENSITY** (the amount of energy stored in a given volume) of fossil fuels is very high, much higher than biomass.

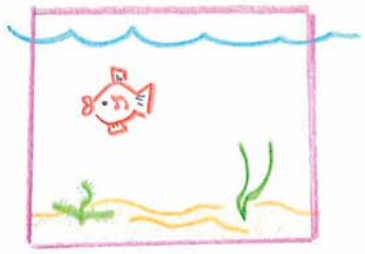
What about $CO_2$ emissions?

Burning biomass will release $CO_2$ into our atmosphere, impacting our climate. If crops are replanted, the new crops could **OFFSET** these emissions by absorbing $CO_2$ as they grow. The $CO_2$ released from fossil fuels may have a greater impact on our climate because fossil fuels release $CO_2$ that has been absent from the atmosphere for millions of years.

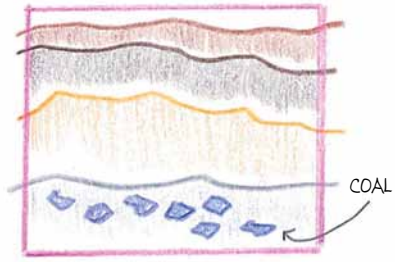
Each type of biomass used to generate electricity has its own advantages and disadvantages. For example, using crops to generate electricity on a large scale may require large amounts of energy, fertilizers, and land. Depending on how and where crops are grown, this could reduce the land available to grow food, impacting food security and global food prices.

# Energy Source: Coal

**FOSSIL FUELS** are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of oil, natural gas, and **COAL**.



MILLIONS OF YEARS AGO




TODAY

Coal is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of coal in the world is **FINITE**.

There are 4 different kinds of coal—each contains a different amount of carbon. Each kind also contains a different amount of energy.

Coal is found all over the world, but the United States, Russia, and China possess the largest reserves. Coal is mined in 25 states, the most significant of which are Wyoming, West Virginia, Kentucky, Pennsylvania, and Texas.

Coal is generally one of the most abundant fuel sources in the United States. The primary use of coal is for electricity.

How do we get it out of the ground?

## MINING

Coal can be found right on Earth's surface or hundreds of feet below ground.

Surface mining techniques include **STRIP MINING** (stripping the plants, soil and rock from the surface to get at the coal) and **MOUNTAIN TOP REMOVAL** (removing entire mountain tops to get at the coal).

Mining releases a great deal of ash and dust, air pollutants, into the local environment and this pollution can result in acid rain. Also, using coal for electricity production releases more $CO_2$ than any other energy source.

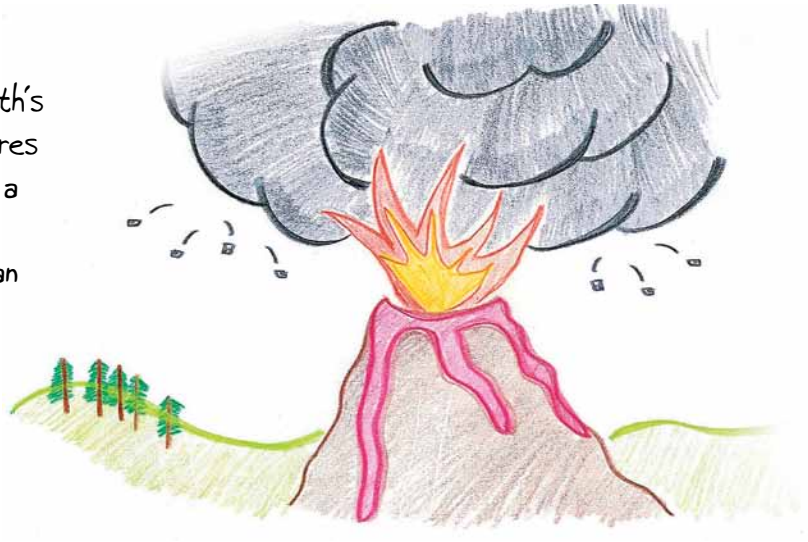
**UNDERGROUND MINING** involves a lot of digging as well as the construction of mine shafts and elevators to bring miners below ground to extract the coal. Underground mine workers are vulnerable to health hazards like respiratory illnesses and lung disease.

Transporting coal to power plants requires that energy be used to fuel coal trains, trucks, and barges—especially since coal, as a solid, cannot be moved along a pipeline.

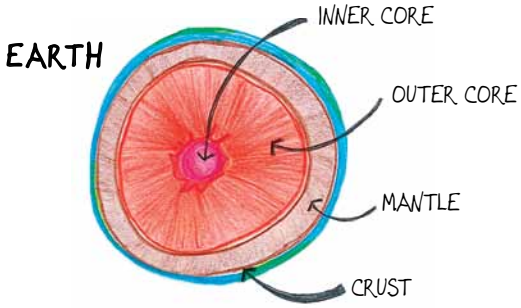
What does it mean when people use the phrase **CLEAN COAL**? "Clean coal" refers to technologies (sometimes called scrubbers or cleaners) developed to capture and store air pollutants generated from the combustion of coal before they enter the atmosphere.

# **Energy Source:** Geothermal

The constant decay of radioactive particles in Earth's molten iron core produces extremely hot temperatures (hotter than the sun's surface). This slow decay is a process occurring in all rocks. The heat generated is referred to as **GEOTHERMAL** energy and can be used to produce electricity.



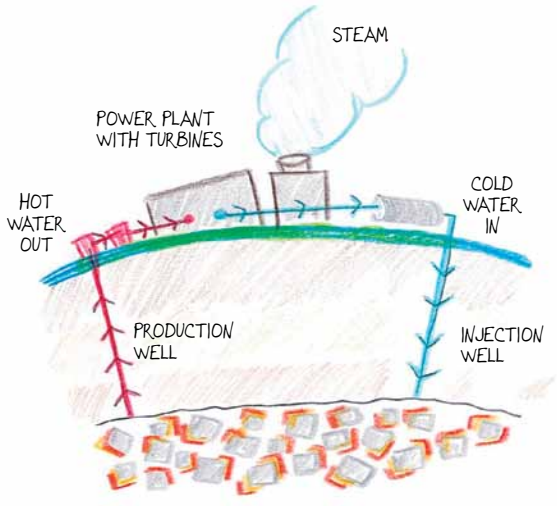
Geothermal energy is considered a **RENEWABLE** energy source because heat is being generated continuously in Earth's core.




While geothermal **RESERVOIRS** may be hard to reach deep beneath Earth's surface, **VOLCANOES**, **HOT SPRINGS**, and **GEYSERS** are a good sign of geothermic activity below. However, drilling is required to confirm hot temperatures below, and not all reservoirs will have visible clues at the surface.

Building a geothermal power plant can be very expensive. In addition, drilling for geothermal reservoirs may affect land stability in the area. Geothermal energy is not dependent upon weather, unlike wind and solar. Geothermal power plants also emit less than 1% of the $CO_2$ emissions that fossil fuel power plants emit.

Once a reservoir is found, pipelines are drilled 1 to 2 miles below the surface to reach steam or water as hot as 700°F. Some geothermal plants take steam directly from Earth to power a generator; other plants take hot water and convert it to steam to power the generator. Either method will take the steam or water used to generate electricity and inject it back in the ground to reheat.

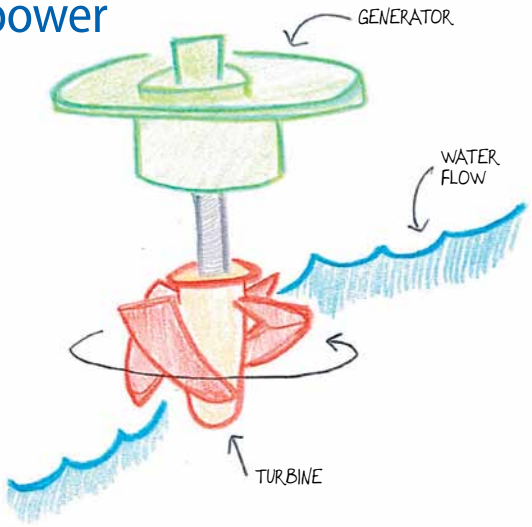



GEOTHERMAL RESERVOIR

Currently, the United States, the Philippines, and Iceland have the most geothermal power plants. California has 36 geothermal power plants, the most of any state.

Geothermal energy may rely on water from Earth's core that contains chemicals harmful in high doses such as **HYDROGEN SULFIDE** which smells like rotten eggs. Geothermal power plants may be designed to capture these chemicals before they are released into the atmosphere.

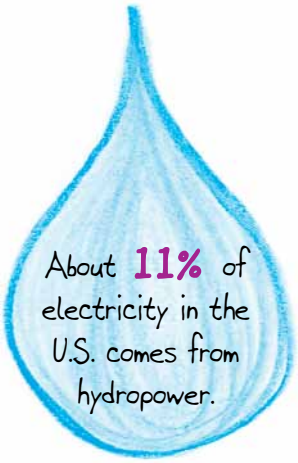
# **Energy Source:** Hydropower




**HYDROPOWER** refers to the **KINETIC ENERGY** of moving water. The amount of kinetic energy will depend on flow or fall.

Hydropower is considered a **RENEWABLE** energy source because water is continuously moving as a result of Earth's water cycle.

Water is denser than air. Because of this, more energy may be captured from a water turbine than a wind turbine. However, the density also requires a sturdier structure to capture the energy. As a result, hydropower projects are often more expensive.

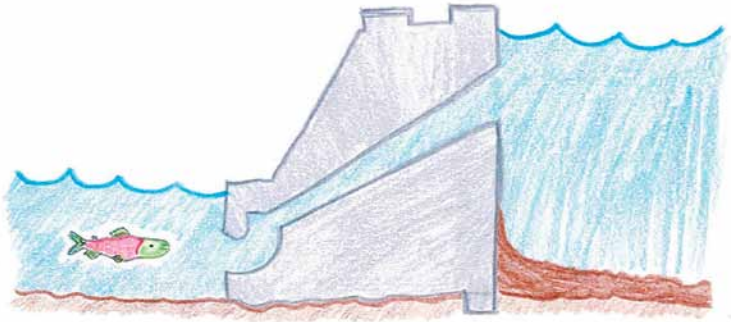



One common way to harness the energy of moving water is to build a **HYDROELECTRIC DAM** (not all dams are constructed for energy use) along a river. Releasing water from a **RESERVOIR** (the body of water held behind a dam) can push water fast enough against a turbine to spin its blades, generating electricity. Rivers already moving fast enough to turn the blades of a turbine may not require a dam. **RUN-OF-THE-RIVER** or **DIVERSION** designs can harness the energy of these fast moving rivers.

We can also capture the energy of **TIDES** and **WAVES** using other technologies, but all technologies funnel water along a path that is pushed against a turbine.

Hydropower has been used for thousands of years. Today, in the United States, hydropower is mostly used to generate electricity.

Large dams can have significant **SOCIAL** and **ENVIRONMENTAL** impacts. When constructed, dams will often flood dry land near the reservoir, as water backs up behind the dam. Many living in the area are forced to move.

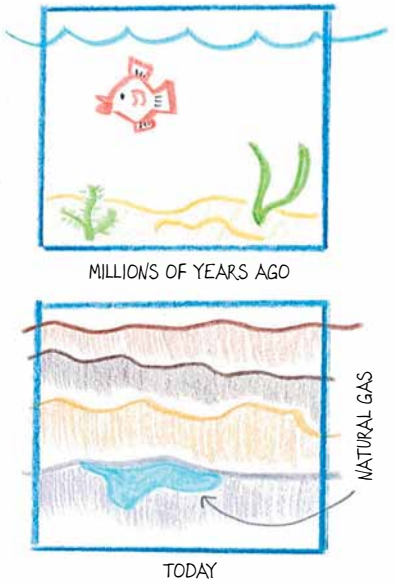


Changing the path of a river can have harmful effects on other organisms. Dams prevent the migration of fish, such as **SALMON**. Fish ladders have been developed at many dams to help the fish swim past, but many cannot navigate their way through the structure. Also, **SEDIMENTS** (soil, sand, and leaves) can build up in reservoirs. These sediments reduce water quality for organisms that live in the water and can choke out sunlight.

There have been community efforts to remove dams built long ago and to restore river and surrounding ecosystems to their natural state. For instance, the Elwha Dam in Washington State was removed in 2012 to help restore local fisheries.

# **Energy Source:** Natural Gas

**FOSSIL FUELS** are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of coal, petroleum, and **NATURAL GAS**.



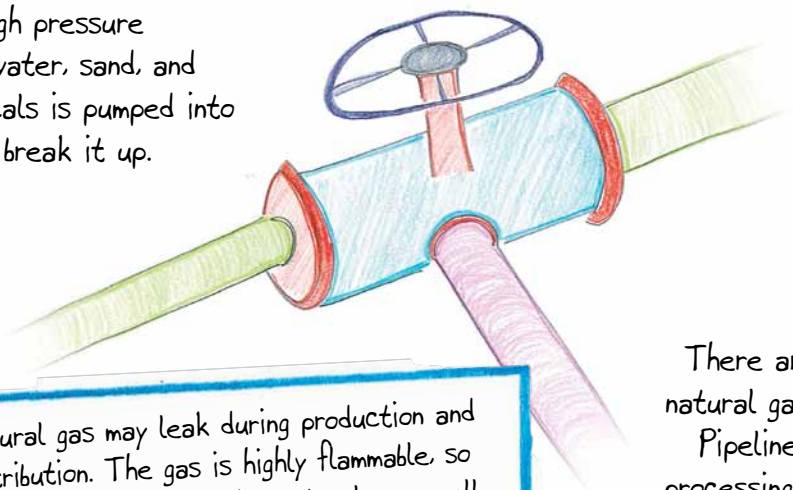

Geologists search for natural gas by studying underground rock formations and setting off explosions to record sound waves.

How do we get it out of the ground?

## DRILLING and FRACTURING

We use a variety of techniques to extract natural gas from the ground. One is called hydraulic fracturing (or fracking). To release natural gas trapped in rock, a high pressure mixture of water, sand, and toxic chemicals is pumped into the rock to break it up.

Natural gas reserves are often found in wilderness areas. Extraction can involve destruction of the natural environment and harm to local plants and animals. Chemicals used in fracking may also contaminate local water sources and drilling has been known to leave the ground unstable.

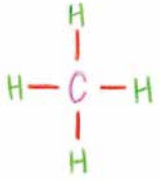


Natural gas may leak during production and distribution. The gas is highly flammable, so an odor is added to make natural gas smell like rotten eggs so that serious leaks can be immediately detected.

Natural gas is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of natural gas in the world is **FINITE**.

Texas, Wyoming, Louisiana, and Oklahoma are top natural gas producing states. The United States also imports natural gas from Canada. Russia possesses the largest natural gas reserves in the world.

Natural gas is a colorless, odorless hydrocarbon that is mostly composed of methane (a molecule made of 1 carbon atom and 4 hydrogen atoms).




**METHANE** has a greenhouse effect 72 times greater than $CO_2$ and may be released during extraction, transport, and distribution of natural gas. A growing dependence on natural gas will lead to a rise in methane emissions.

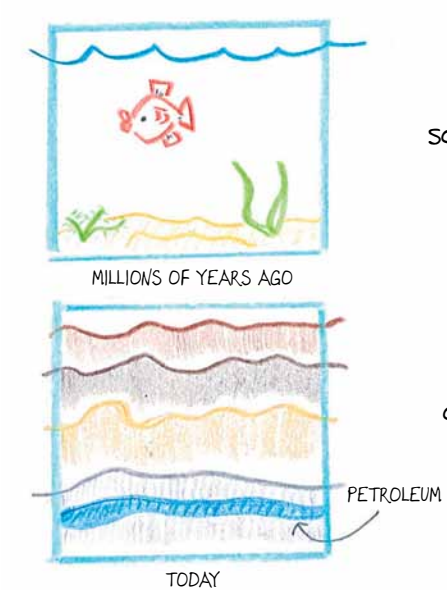
How do we transport it?

## PIPELINES

There are more than 300,000 miles of natural gas pipelines in the United States. Pipelines move natural gas to plants for processing and storage. Gas is often saved until winter when energy needs are high. Then natural gas is transferred to power plants and burned to create electricity.

# **Energy Source:** Petroleum (oil)

**FOSSIL FUELS** are energy sources created over millions of years from the remains of living organisms. Years of being buried under layers of earth or water exposes these remains to heat and pressure, which transforms them into fossil fuels in the form of coal, natural gas, and **PETROLEUM**.




Petroleum is considered a **NONRENEWABLE** energy source because it takes so long to form. The amount of oil in the world is **FINITE**.

To find petroleum reserves, geologists study underground rock formations to predict where oil is likely to be found. In 2010, only 61% of exploratory wells found oil.

Petroleum has been found in 31 states, but mostly in Alaska, California, North Dakota, Oklahoma, and Texas. We import about $^1/_2$ the petroleum we use, mainly from Canada and Mexico. The Middle East possesses the world's largest petroleum reserves.

Petroleum has been burned to produce light for thousands of years in places like China and Egypt.

How do we access it?

## DRILLING

We use a drilling rig and derrick to pump the oil up from thousands of feet below ground. We also drill into the ocean floor to access oil reserves. **OFFSHORE** drilling is more expensive. Currently over $^1/_3$ of our oil supply is extracted from offshore wells. Typically, 1 oil well produces about 10 barrels of crude oil a day. Though the longer we drill at one well the less oil we extract over time.

How do we process it?

## REFINEMENT

Once pumped from the ground, oil is sent to a refinery where it can be separated out by weight and boiling point into gasoline, diesel, heating oil, jet fuel, etc. Contaminates such as sulfur are also removed in the refining process. Once refined, oil can be burned at a power plant to produce electricity.

Petroleum products include gasoline, fertilizers, pesticides, plastics, and medicines.

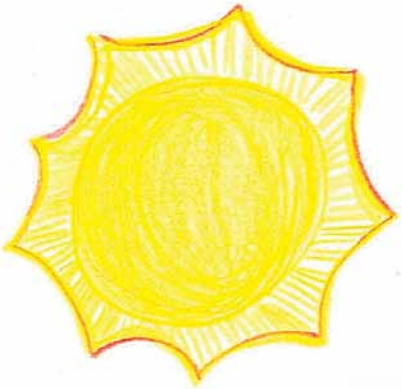
How do we transport it?

## PIPELINES, BARGES, and TRUCKS, oh my!

We have to transport oil all over the United States. Since WWII, oil has replaced coal as our primary energy resource. Petroleum is popular because it is more energy dense than coal or natural gas. However, only 1% of our petroleum consumption is used to produce electricity, while 71% is used to power our transportation sector.

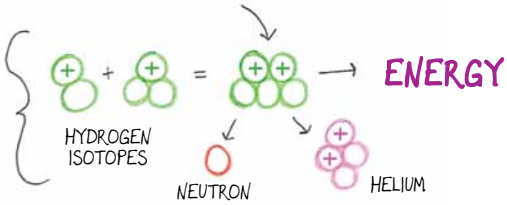
The processing, combustion, and disposal of petroleum often creates air and water pollution. The emission of $CO_2$, a greenhouse gas, is a big health and environmental cost of petroleum. Oil spills are frequent and can harm wildlife, pollute water, and release noxious fumes.

# Energy Source: Solar



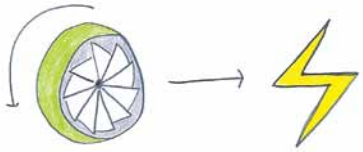
The sun produces **RADIANT** energy as gasses in its core undergo **NUCLEAR FUSION**. This energy travels through space and reaches Earth as it orbits the sun. Solar is considered a **RENEWABLE** energy source because the sun's energy production is constant.

This energy can be used to generate electricity in **2** ways.



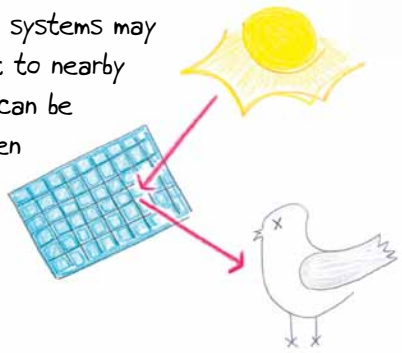

We can convert the sun's energy into electricity using **SOLAR THERMAL SYSTEMS**. Solar thermal systems use a variety of methods (from mirrors to dishes)

that concentrate the sun's rays toward one spot to heat water and turn it into steam. The steam is then used to turn a turbine, which generates electricity through motion.



This is similar to the process used by power plants that burn fossil fuels to generate electricity. However, no carbon dioxide is emitted as a result of solar thermal systems.

Solar thermal systems may pose a threat to nearby wildlife that can be caught between the mirrors and their trajectory.

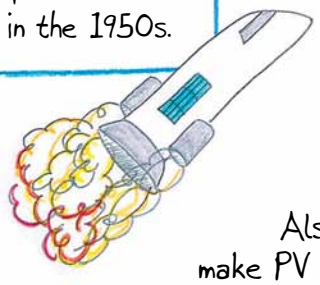


Silicon can be extracted from sand. Silicon will not act as a semi-conductor forever. Eventually the silicon will need to be replaced.

We can convert the sun's energy into electricity using **PHOTOVOLTAIC (PV) CELLS**.

PV cells are made of semiconductors such as pure silicon. The cells are grouped together in panels. You can find PV cells on rooftop solar panels, as well as in watches, calculators, and space shuttles.

PV cells were first used on space shuttles in the 1950s.

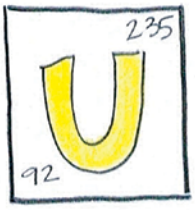


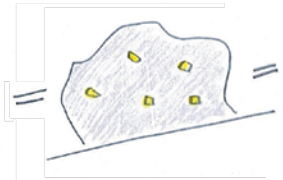
PV cells are not as efficient as fossil fuels with current technology. PV cells convert 11-27% of the sun's radiant energy into electrical energy. Burning fossil fuels converts 35% of their chemical energy into electrical energy.

Also, toxic chemicals are often used to make PV cells. These toxic chemicals must be handled and disposed of properly in order to keep the environment and the people in the local community safe.

The availability of solar power depends upon weather, time of day, and location. Catching all that sunshine requires a great deal of surface area, since the sun's energy is not concentrated.

# **Energy Source:** Uranium



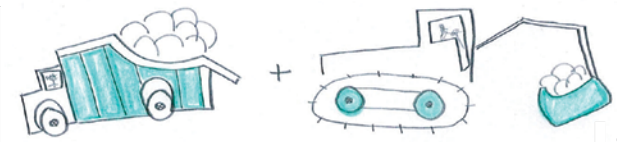



3rd most common energy source for electricity in the United States

Uranium is a **NONRENEWABLE** metal found in rocks all over the world. Uranium is the most common element used by power plants that generate energy by **NUCLEAR FISSION** because the uranium atom splits more easily than other atoms. Uranium is more common than silver, but most uranium has to be enriched into a form that can be used by nuclear power plants (U-235).

## How do we get Uranium?

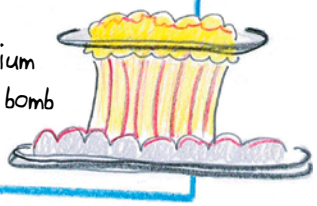
We **MINE** for it!



We mine for uranium using a variety of techniques including solution, open pit, underground, and heap leaching mining. We mine for uranium all over the world.

The mining process itself uses a lot of energy (fuel and electricity). For example, solution mining involves dissolving the uranium ore in a solution and then pumping it to the surface.

The use of uranium was first developed in the 1930s. Uranium was used to create the atom bomb dropped during WWII.

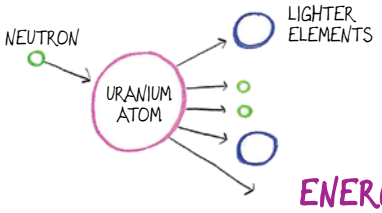


## What's next? We **PROCESS** it!

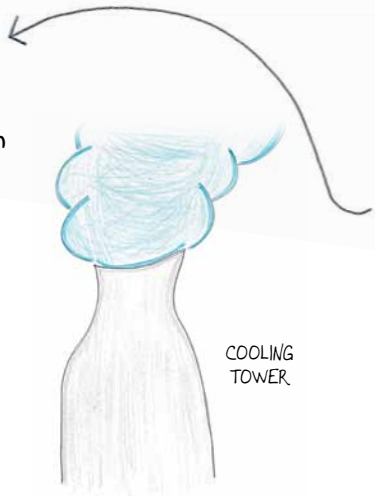
1. We crush uranium ore up and treat it with chemicals to separate the uranium from the rock.
2. We collect and dry the remaining substance, called yellowcake, and convert it into a gas.
3. We enrich the uranium to make it more concentrated.
4. We then package the uranium into pellets the size of your fingertip. Each pellet contains a potential energy equal to 150 gallons of oil.

## Now what? **FISSION!**

We transport the enriched uranium to a nuclear reactor facility where fission can occur. In fission, uranium atoms are split to release energy.




**ENERGY!**


This heat is used to boil water into steam. The steam is then used to power a turbine to generate electricity.

Nuclear reactors do not create air pollution, unlike power plants that burn fossil fuels for energy. They do create **RADIOACTIVE WASTE** that lasts tens of thousands of years.

## What do we do with the waste?

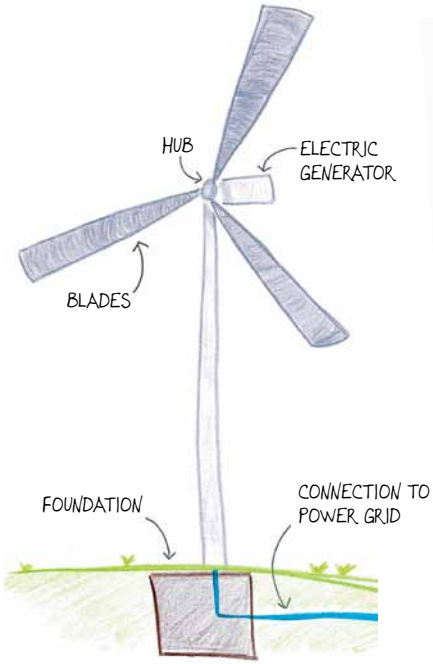
**NOT SURE.**

We keep uranium waste (spent fuel) in cool pools of water or bury it deep below the ground. But these are temporary fixes. We have not yet developed a permanent storage method. Uranium waste can release radiation back into the environment, where it poses a threat to ecosystems and human health. Radiation can cause birth defects, cancer, and death.

# **Energy Source:** Wind

The uneven heating of Earth's surface produces **WIND** energy. Earth is warmed unevenly for a variety of reasons: the poles are farther from the sun than the equator and Earth's surfaces vary, some absorbing the sun's energy easily (dark sea), while other surfaces are more reflective (ice).

Wind has been used as an energy source for thousands of years to propel boats and pump water. Wind energy can also be converted into electricity with wind **TURBINES**. Wind turbines can be built on land or offshore, wherever wind is consistent. The wind causes the turbine's blades to spin. The blades are connected to a drive shaft, which turns an electric generator, converting **KINETIC ENERGY** into electricity.

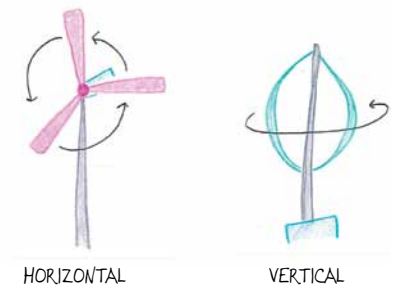



Some ranchers and farmers have installed wind turbines on their land to make a little extra money and save on their energy bills. With the added income from wind power, farmer and ranchers are better able to preserve their forest, grazing, or farmland and for continued agricultural use.

Wind is considered a **RENEWABLE** energy source because the relationship between Earth and the sun will constantly generate wind, though some places are better suited for wind energy production than others.

The best locations for **WIND FARMS** (where a group of wind turbines are built to produce electricity) are open areas without wind breaks. The biggest wind farm is in Texas, with over 400 wind turbines, generating enough electricity to power 220,000 homes each year. In 2012, 3% of U.S. electricity came from wind. Denmark relies on wind power for 19% of its electricity.

Wind turbines come in 2 forms: **VERTICAL** and **HORIZONTAL**. Horizontal is the more commonly used. Horizontal turbines may be as tall as a 20-story building with blades longer than a football field.




Converting wind energy into electricity creates little pollution and the fuel (wind) is free! Wind turbines, however, are often built from steel and other **MINERALS**, resources extracted from the ground through mining. Wind turbines may pose a threat to wildlife, including birds and bats.